Summary

Working Group III, *Climate Change 2001: Mitigation*
Third Assessment Report of the
Intergovernmental Panel on Climate Change

Senate Committee on Commerce,
Science and Transportation

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1 May 2001

The IPCC WG III review of studies on climate change mitigation describes the potential and costs of technologies, practices, and policies to (1) reduce near-term annual greenhouse gas (GHG) emissions, and (2) stabilize atmospheric GHG concentrations over the long-term.

Reduction of Near-term Annual GHG Emissions:

1. Significant unanticipated technical progress relevant to greenhouse gas reductions has been achieved since the IPCC released its Second Assessment Report in 1996.
2. Technologies such as efficient hybrid engine cars, fuel cells, underground carbon dioxide storage, and many others have the potential to reduce global GHG emissions in 2010 - 2020 to below 2000 levels.
3. In the absence of barriers, studies suggest that about half of the above emissions reduction potential can be achieved with direct benefits exceeding direct costs, and the other half at a net direct cost of up to US $ 100/t C_{eq} (at 1998 prices). Overcoming barriers such as subsidized prices, lack of access to information and financing, and ill defined property rights will incur additional costs, which in some cases may be substantial.
4. National responses can be more effective if deployed as a portfolio of policy instruments to reduce greenhouse gas emissions.
5. About a dozen studies based on models of the global economy estimate that costs to the US economy of meeting GHG emissions levels noted in the Kyoto Protocol vary from 0.4-2.0 % of 2010 GDP.
6. Assuming full GHG emissions trading both within and across industrialized countries, these studies show that costs can be reduced to less than half the above values.
7. Costs may be further reduced through implementation of carbon offset projects in developing countries, and land use, land-use change and forestry (LULUCF)

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activities, mitigation options that also reduce local pollutants, and revenue neutral carbon taxes.

Stabilization of Long-term (2100+) Atmospheric GHG Concentrations:

8. Widespread use of known technological options could achieve a broad range of atmospheric carbon dioxide stabilization levels such as 550, 450 ppmv or below (compared to 368 ppmv in 2000) over the next 100 years or more, if the type of barriers noted in item 3 above could be overcome.

9. The cost of achieving stabilization will depend on the emissions pathway and the targeted stabilization level. Least-cost studies show that decreasing the stabilization target makes annual emissions peak earlier and at lower levels before beginning a gradual decline, and vice versa. Estimated costs of stabilizing carbon dioxide concentrations increase steeply as the level declines below 550 ppmv.

10. Stabilization will require the participation of all countries. Two-thirds of IPCC Post-SRES scenarios show that annual GHG emissions per capita from industrialized countries decline to levels below those of developing countries by 2050.

11. IPCC emissions scenarios indicate a severe depletion of conventional oil and gas resources by mid-century or earlier. This offers an opportunity for a transition to less-carbon-intensive energy sources and technologies.

12. Investment in energy R&D, the transfer and adoption of existing technology, and technological and social innovation will be required to foster the penetration of these energy sources and improved technologies.

Results and Conclusions

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Statement to the
Senate Committee on Commerce,
Science and Transportation

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1 May 2001

Mr. Chairman, thank you for inviting me to speak about the findings of the Working Group (WG) III on *Climate Change 2001: Mitigation* of the Intergovernmental Panel on Climate Change (IPCC). I served as a Coordinating Lead Author of the Chapter on Barriers, Opportunities, and Market Potential of Technologies and Practices of the WG III report, and an author of the Synthesis Report, and have participated in the discussions and writing of their Summaries for Policy Makers (SPM). My remarks today are based largely on the SPM findings and the contents of the underlying report. In this statement, I have focused on the near- and long-term potential for, and costs and benefits of, reducing greenhouse gas emissions.

1. There are many low cost technological options to reduce near-term emissions, but barriers to their deployment exist.

<u>Significant technical progress</u> relevant to the potential for greenhouse gas emission reductions has been made since 1995 and has been faster than anticipated. Net emissions reductions could be achieved through, inter-alia, improved production and use of energy, shift to low- or no-carbon technologies, carbon removal and storage, and improved land-use, land-use change and forestry (LULUCF) practices. Relevant advances are taking place in a wide range of technologies at different stages of development, ranging from the market introduction of efficient hybrid engine cars to the advancement of fuel cell technology, and the demonstration of underground carbon dioxide storage.

<u>The successful implementation</u> of greenhouse gas mitigation options <u>would need to overcome</u> many technical, economic, political, cultural, social, behavioral and/or institutional <u>barriers</u> which prevent the full exploitation of the technological, economic and social opportunities of these mitigation options (Figure 1). The potential mitigation

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opportunities and types of barriers vary by region and sector, and over time. In the industrialized countries, future opportunities lie primarily in removing social and behavioral barriers, in countries with economies in transition, in price rationalization; and in developing countries, in price rationalization, increased access to data and information, availability of advanced technologies, financial resources, and training and capacity building. Most countries could benefit from innovative financing and institutional reform and removing barriers to trade.

***National responses** to climate change **can be more effective** if deployed as a **portfolio of policy instruments** to limit or reduce greenhouse gas emissions.* The portfolio may include -- according to national circumstances- emissions/carbon/energy taxes, tradable or non-tradable permits, subsidies, deposit/refund systems, technology or performance standards, product bans, voluntary agreements, government spending and investment, and support for research and development.

Annual global emissions reductions of 1.9-2.6 GtC_{eq}, and 3.6 - 5.0 GtC_{eq} per year could be achieved by 2010 and 2020 respectively, with half of these reductions being realized with direct benefits exceeding direct costs, and the other half at a net direct cost of up to US\$100/tC_{eq} (at 1998 prices). Depending on the emissions scenario this could allow global emissions to be reduced below 2000 levels in 2010-2020 (Table 1). These cost estimates are derived using discount rates in the range of 5 to 12 percent, consistent with public sector discount rates, but lower than private internal rates of return, thus affecting the rate of adoption of these technologies by private entities. Realising these reductions involves, among other things, additional implementation costs, which in some cases may be substantial, the possible need for supporting policies, increased research and development, and effective technology transfer.

2. Based on models of the global economy the cost estimates of meeting GHG emissions levels noted in the Kyoto Protocol vary considerably both within and across regions

Models show that the Kyoto mechanisms can reduce costs to Annex II[3] countries. Global modeling studies show national marginal costs to meet the Kyoto emissions levels range from about US\$20/tC up to US\$600/tC without trading, and from about US\$15/tC up to US\$150/tC with Annex B[4] trading. Figure 2 shows the range of GDP losses estimated in these studies in 2010. The cost reductions and GDP losses from these mechanisms may depend on the details of implementation, including the compatibility of domestic and international mechanisms, constraints, and transaction costs. These costs can be further reduced through use of the Clean Development Mechanism, LULUCF activities, by including the non-carbon dioxide gases, identifying and implementing options that produce ancillary benefits, and identifying double dividend opportunities,

3 Annex II: Countries listed in the Annex II of the UN Framework Convention on Climate Change. Annex II list includes the United States and 23 other original members of the Organization for Economic Cooperation and Development (OECD), plus the European Union.

4 Annex B: Annex I countries that are listed in the Kyoto Protocol to take on commitments to limit their emissions.

e.g., carbon taxes or auctioned permits may be used to finance reductions in existing distortionary taxes, reducing the economic cost of achieving greenhouse gas reductions.

Emission constraints in Annex I[5] countries have well established, albeit varied "spill over" effects on non-Annex I countries, including:
Oil-exporting, non-Annex I countries: The study reporting the lowest costs, reported reductions in projected GDP of 0.2% with no emissions trading, and less than 0.05% with Annex B emissions trading in 2010. The study reporting the highest costs shows reductions of projected oil revenues of 25% with no emissions trading, and 13% with Annex B emissions trading in 2010.
Other non-Annex I countries may be adversely affected by reductions in demand for their exports to OECD nations and by the price increase of those carbon-intensive and other products they continue to import, but may benefit from the reduction in fuel prices, increased exports of carbon-intensive products and the transfer of environmentally sound technologies and know-how.

3. Technology development and diffusion are an important component of cost-effective stabilization

Transfer of existing technologies and the development and transfer of new technologies could play a critical role in reducing the cost of stabilizing greenhouse gas concentrations. Transfer of technologies between countries and regions could widen the choice of options at the regional level and economies of scale and learning will lower the costs of their adoption. Governments through sound economic policy, and regulatory frameworks, transparency and political stability could create an enabling environment for private and public sector technology transfers and adequate human and organizational capacity is essential at every stage to increase the flow, and improve the quality, of technologies. In addition, networking among private and public stakeholders, and focusing on products and techniques with multiple ancillary benefits, that meet or adapt to local needs and priorities, is essential for most effective technology transfers.

IPCC emissions scenarios indicate that conventional oil and gas resources will be mostly used up by mid-century irrespective of actions to address climate change (Figure 3). This will necessitate a different pattern of energy resource development and an increase in energy R&D with the goal of accelerating the development and deployment of advanced energy technologies. Given that the carbon in proven conventional oil and gas reserves, or in conventional oil resources, is limited, this may imply a change in the energy mix and the introduction of new sources of energy during the 21st century. If so, the choice of energy mix and associated investment will determine whether, and if so, at what level and cost, greenhouse concentrations can be stabilized. Opportunities that exist in the near term are the fruits of past investments in energy R&D; therefore, further investments in energy R&D will be required to maintain the flow of improved energy technologies throughout the 21st century.

[5] Annex I: Annex II countries plus the countries designated as Economies in Transition.

Technological and social innovation could raise the social and economic potential of mitigation options beyond that of current markets. In the longer term, such innovations may shift preferences and cultural norms towards lower-emitting and sustainable behaviors.

4. Both the pathway to stabilization of atmospheric GHG concentrations and the stabilization target itself are key determinants of mitigation costs

Stabilization levels depend more on cumulative rather than year-by-year emissions. A gradual near-term transition away from the world's present energy system towards a less carbon-emitting economy minimizes costs associated with premature retirement of existing capital stock and provides time for technology development, and avoids premature lock-in to early versions of rapidly developing low-emission technology, where-as more rapid near-term action would decrease environmental and human risks associated with projected changes in climate and may stimulate more rapid deployment of existing low-emission technologies and provide strong near-term incentives to future technological changes.

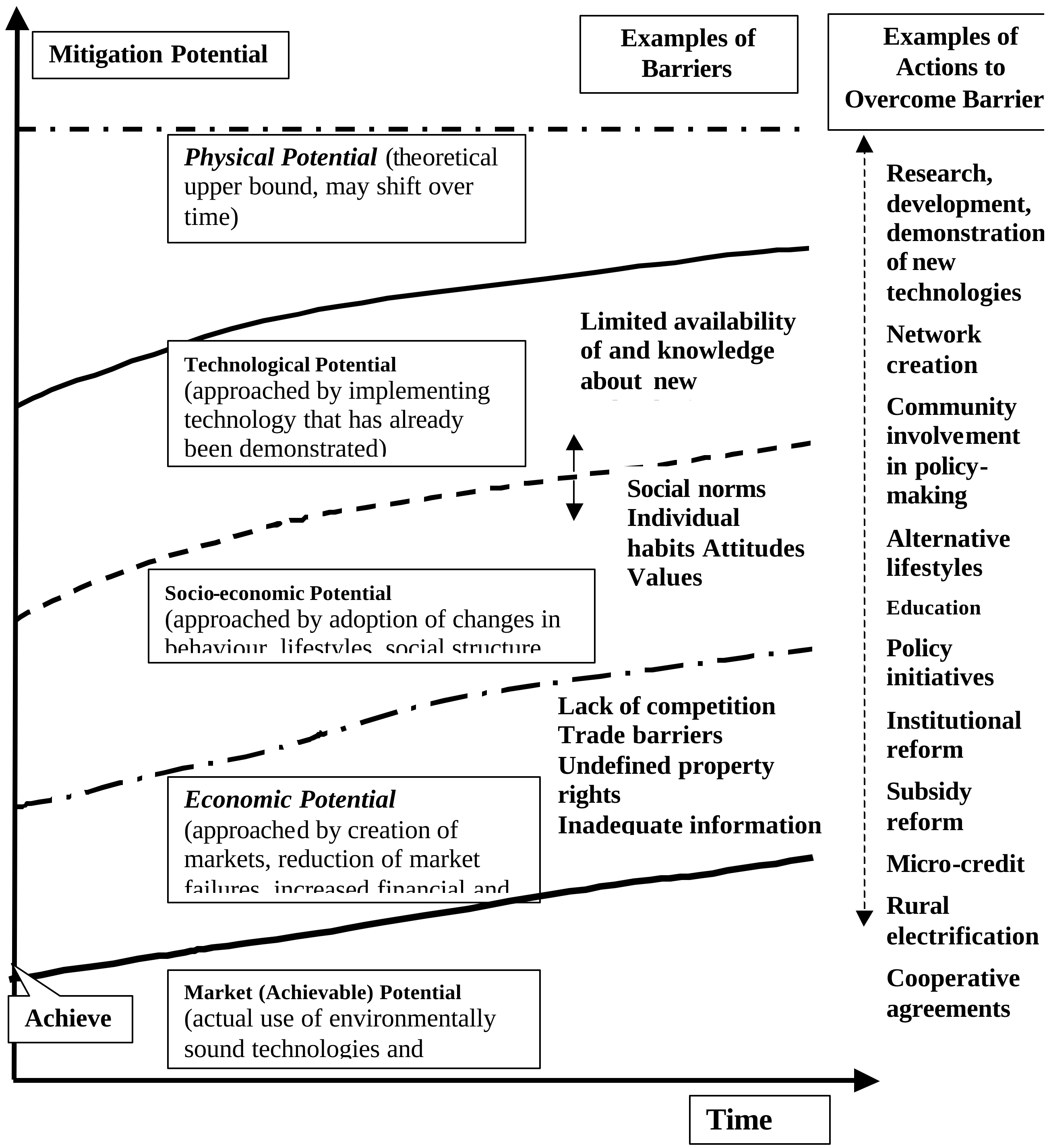
Studies show that the costs of stabilizing carbon dioxide concentrations in the atmosphere increase as the stabilization level declines (Figure 4). While there is a moderate increase in the costs when passing from a 750 ppm to a 550 ppm concentration stabilization level, there is a larger increase in costs passing from 550 ppm to 450 ppm unless the emissions in the baseline scenario are very low. However, these studies did not incorporate carbon sequestration, non-carbon dioxide gases and did not examine the possible effect of more ambitious targets on induced technological change.

Countries and regions will have to choose their own path to a low emissions future, where decision-making is essentially a sequential process under uncertainty. Most model results indicate that known technological options could achieve a broad range of atmospheric carbon dioxide stabilization levels, such as 550 ppm or 450 ppm and below over the next 100 years or more, but implementation would require associated socio-economic and institutional changes. However, no single sector or technology option could provide all of the emissions reductions needed. A prudent risk management strategy requires a careful consideration of the economic and environmental consequences, their likelihood and society's attitude toward risk.

Stabilization of atmospheric GHG levels will require the participation of all countries in the long term. Two-thirds of IPCC Post-SRES scenarios show that annual GHG emissions per capita from industrialized countries decline to levels below those of developing countries by 2050.

Figure 1: Penetration of Environmentally Sound Technologies (including Practices): A Conceptual Framework

Various barriers prevent the different potentials from being realized. Opportunities exist to overcome barriers through innovative projects, programs and financing arrangements. An action can address more than one barrier. Actions may be pursued to address barriers at all levels simultaneously. Their implementation may require public policies, measures and instruments. The socioeconomic potential may lie anywhere in the space between the economic and technological potential.



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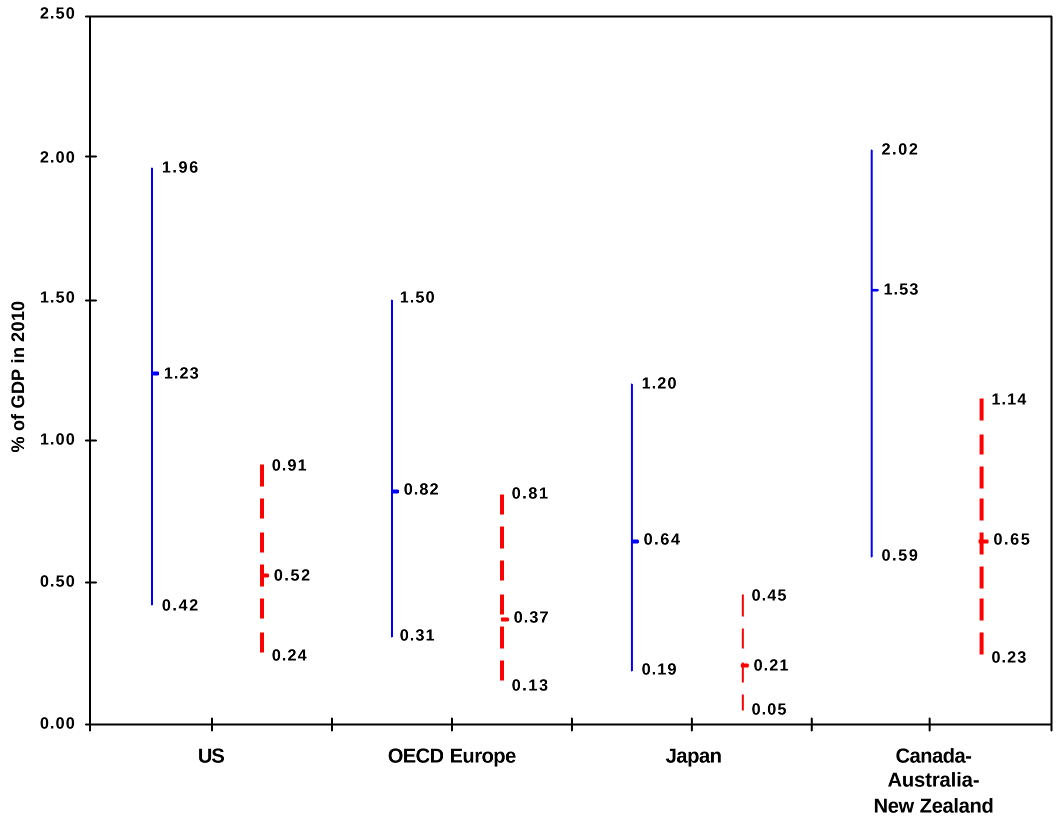
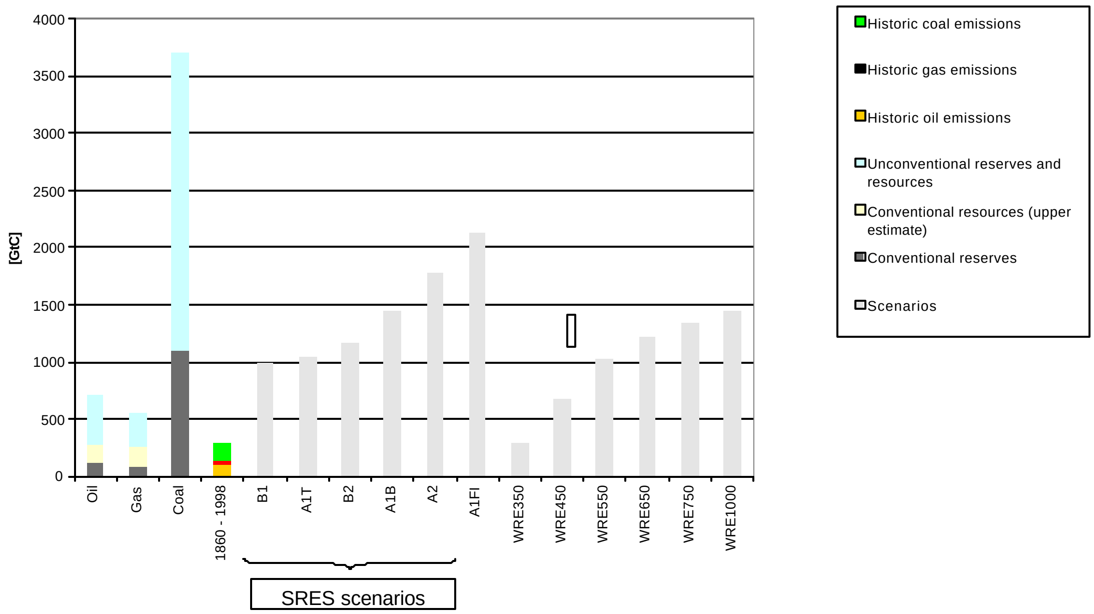


Figure 2. Global model projections of GDP losses in Annex II in 2010. The projections are from the Energy Modeling Forum study cited in WGIII Section 8.3.1.1. The global models used in that study dissagregate the world into regions. The projections reported in the figure are for four regions, which constitute Annex II. The models examined two scenarios. In the first, each region must make the prescribed reduction in the absence of international trade in carbon emissions rights (solid lines). In the second, full Annex B trading is permitted (dashed lines). For each region, the maximum, minimum, and average of the model projections are shown.

Figure 3. Carbon in oil, gas and coal reserves and resources compared with historic fossil fuel carbon emissions 1860-1998, and with cumulative carbon emissions from a range of SRES scenarios and TAR stabilization scenarios up until 2100. Data for reserves and resources are shown in the left hand columns (Section 3.8.1). Unconventional oil and gas includes tar sands, shale oil, other heavy oil, coal bed methane, deep geopressured gas, gas in acquifers, etc. Gas hydrates (clathrates) that amount to an estimated 12,000 GtC are not shown. The scenario columns show both SRES reference scenarios as well as scenarios which lead to stabilization of CO_2 concentrations at a range of levels. Note that if by 2100 cumulative emissions associated with SRES scenarios are equal to or smaller than those for stabilization scenarios, this does not imply that these scenarios equally lead to stabilization.



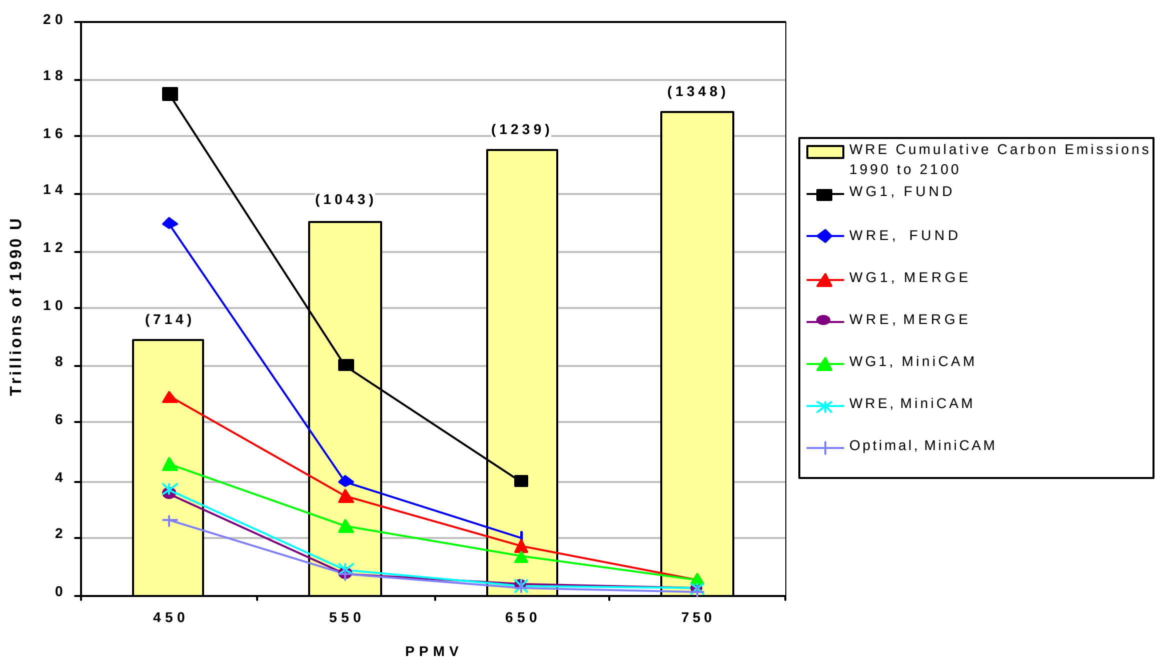


Figure 4. The costs (discounted present value) of stabilizing CO2 concentrations at 450-750ppmv are calculated using three global models. In each instance, costs were calculated based on two emission pathways for achieving the prescribed target: WGI or S and WRE. The MiniCam model was also used to identify the least-cost emissions pathway. The bar chart shows cumulative carbon emissions between 1990 and 2100.

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Table 1. Estimates of potential global greenhouse gas emission reductions in 2010 and in 2020

Sector		Historic emissions in 1990 [$MtC_{eq.}$/yr]	Historic $C_{eq.}$ annua growth rate in 1990-1995 [%]	Potential emission reductions in 2010 [$MtC_{eq.}$/yr]	Potential emission reductions in 2020 [$MtC_{eq.}$/yr]	Net direct costs per tonne of carbon avoided
Buildings[a]	CO_2 only	1650	1.0	700-750	1000-1100	Most reductions are available at negative net direct costs.
Transport	CO_2 only	1080	2.4	100-300	300-700	Most studies indicate net direct costs less than $25/tC but two suggest net direct costs will exceed $50/tC.
Industry	CO_2 only	2300	0.4			
-energy efficiency:				300-500	700-900	More than half available at net negative direct costs.
-material efficiency:				~200	~600	Costs are uncertain.
Industry	Non-CO_2 gases	170		~100	~100	N_2O emissions reduction costs are $0-$10/$tC_{eq.}$.
Agriculture [b]	CO_2 only	210				Most reductions will cost between $0-100/$tC_{eq.}$ with limited opportunities for negative net direct cost options
	Non-CO_2 gases	1250-2800	n.a	150-300	350-750	
Waste [b]	CH_4 only	240	1.0	~200	~200	About 75% of the savings as methane recovery from landfills at net negative direct cost; 25% at a cost of $20/$tC_{eq.}$.
Montreal Protocol replacement applications	Non-CO_2 gases	0	n.a.	~100	n.a.	About half of reductions due to difference in study baseline and SRES baseline values. Remaining half of the reductions available at net direct costs below $200/$tC_{eq.}$.
Energy supply and conversion[c]	CO_2 only	(1620)	1.5	50-150	350-700	Limited net negative direct cost options exist; many options are available for less than $100/$tC_{eq.}$.
Total		6,900-8,400[d]		1,900-2,600[e]	3,600-5,050[e]	

[a] Buildings include appliances, buildings, and the building shell.

[b] The range for agriculture is mainly caused by large uncertainties about CH_4, N_2O and soil related emissions of CO_2. Waste is dominated by methane landfill and the other sectors could be estimated with more precision as they are dominated by fossil CO_2.

[c] Included in sector values above. Reductions include electricity generation options only (fuel switching to gas/nuclear, CO_2 capture and storage, improved power station efficiencies, and renewables).

[d] Total includes all sectors reviewed in Chapter 3 for all six gases. It excludes non-energy related sources of CO_2 (cement production, 160MtC; gas flaring, 60MtC; and land use change, 600-1400MtC) and energy used for conversion of fuels in the end-use sector totals (630MtC). Note that forestry emissions and their carbon sink mitigation options are not included.

[e] The baseline SRES scenarios (for six gases included in the Kyoto Protocol) project a range of emissions of 11,500-14,000 MtC_{eq} for 2010 and of 12,000-16,000MtC_{eq} for 2020. The emissions reduction estimates are most compatible with baseline emissions trends in the SRES-B2 scenario. The potential reductions take into account regular turn-

Table 1 (Continued). Estimates of potential global greenhouse gas emission reductions in 2010 and in 2020					
Sector	**Historic emissions in 1990 [$MtC_{eq.}/yr$]**	**Historic $C_{eq.}$ annua growth rate in 1990-1995 [%]**	**Potential emission reductions in 2010 [$MtC_{eq.}/yr$]**	**Potential emission reductions in 2020 [$MtC_{eq.}/yr$]**	**Comments**
Land Use, Land-use Change and Forestry					
Afforestation/Reforestation [f] (AR)			197-584		Includes carbon in above and below-ground biomass. Excludes carbon in soils and in dead organic matter.
Reducing Deforestation [f] (D)			1788		Potential for reducing deforestation is very uncertain for the tropics and could be in error by as much as +-50%..
Improved management within a land use [g] (IM)			570		Assumed to be the best available suite of management practices for each land use and climatic zone.
Land-use change [g] (LC)			435		
Total AR, IM, and LC D			 1202-1589 1788		

over of capital stock. They are not limited to cost-effective options, but exclude options with costs above US$100/$tC_{eq}$ (except for Montreal Protocol gases) or options that will not be adopted through the use of generally accepted policies.

F Source: Table 3, SPM, SR LULUCF. Based on IPCC definitional scenario. Information is not available for other definitional scenarios. Potential refers to the estimated range of accounted average stock change 2008-2012 (Mt C/yr^{-1}).

G Source: Table 4, SPM, SRLULUCF. Potential refers to the estimated net change in carbon stocks in 2010 (Mt C/yr^{-1}) . The list of activities is not exclusive or complete, and it is unlikely that all countries will apply all activities. Some of these estimates reflect considerable uncertainty.